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Applicant(s): Shigekazu Orita et al. Examiner: Torres Velazquez, N.L.

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For: ELECTROMAGNETIC WAVE SHIELDING MATERIAL

Assistant Commissioner for Patents
Washington, DC 20231

VERIFIED STATEMENT

I, Takehiko Saito, hereby state that:

1. I am knowledgeable in the English language and in the Japanese language;

2. I have read the English translation of Japanese Appln. No. 2000-199081 from which priority is claimed for U.S. Application No. 09/896,058;

3. I have read Japanese Appln. No. 2000-199081;

4. The English translation of Japanese Appln. No. 2000-199081 is an accurate translation;

5. A true and accurate copy of the English translation is attached hereto;

6. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this Verified Statement is directed.

Date: May 12, 2008

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Applicant	:	SEIREN CO., LTD.

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Inventor:

Address: c/o Seiren Co., Ltd. of
10-1, Keya 1-chome,
Fukui-shi, Fukui, JAPAN

Name: Shigekazu ORITA

Inventor:

Address: c/o Seiren Co., Ltd. of
10-1, Keya 1-chome,
Fukui-shi, Fukui, JAPAN

Name: Toru TAKEGAWA

Inventor:

Address: c/o Seiren Co., Ltd. of
10-1, Keya 1-chome,
Fukui-shi, Fukui, JAPAN

Name: Yasufumi KATSUKI

Inventor:

Address: c/o Seiren Co., Ltd. of
10-1, Keya 1-chome,
Fukui-shi, Fukui, JAPAN

Name: Fumio SHIRASAKI

Applicant:

Id. No.: 000107907

Address: 10-1, Keya 1-chome,
Fukui-shi, Fukui, JAPAN

Name: SEIREN CO., LTD.

Representative: Tatsuo KAWADA

Payment:

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Attachments:

Document Name:	Specification	1
Document Name:	Drawing	1
Document Name:	Abstract	1

[Name of Document]

SPECIFICATION

[Title of the Invention]

ELECTROMAGNETIC WAVE SHIELDING MATERIAL

[Claims]

1. An electromagnetic wave shielding material comprises a fibrous structure base material and a conductive metal layer, wherein the fibrous structure base material is a three dimensionally knitted base material.

2. The electromagnetic wave shielding material of Claim 1, characterized in that the electromagnetic wave shielding material comprises a fibrous structure base material and a conductive metal layer, wherein the fibrous structure base material is a three dimensionally knitted base material composed of an upper ground structure, a lower ground structure and connection thread.

3. The electromagnetic wave shielding material of claim 2, characterized in that the three dimensionally knitted base material has a double raschel structure.

4. The electromagnetic wave shielding material of any one of claims 1 to 3, characterized in that a heat-fusing thread is used at least a portion of the three dimensionally knitted base material.

5. The electromagnetic wave shielding material of any one of claims 1 to 4, characterized in that a conductive metal layer of the electromagnetic wave shielding material is coated with a synthetic resin.

[Field of the Invention]

The present invention relates to an electromagnetic wave shielding material which shields undesirable electromagnetic wave radiated from outside of the environment and also shields electromagnetic wave leaking from inside of the environment.

[Background of the Invention]

In intelligent buildings and FA factories, electronic appliances and communication devices such as personal computers, office-automation devices, factory-automation devices etc. have been generally introduced. As a result, erroneous operations of electronic devices, as well as electronic wave disturbance such as communication disturbance, which occur inside these buildings and factories due to the electromagnetic wave radiated from the electronic appliances and the communication devices as described above or undesirable electromagnetic wave coming from the outside of the environment, have now become a significant social problem.

In order to prevent such leakage of undesirable electromagnetic wave from the environment, as well as erroneous operations of electronic devices and electronic wave disturbance such as communication disturbance due to invasion of extrinsic electromagnetic wave, it has been considered that an information network using optical fibers, coaxial cables or the like is established inside an

intelligent building or a FA factory so that information can be transmitted/received rapidly and accurately. However, there is a problem, in this method, that construction of such a network costs a lot of money. Therefore, there has been proposed another method in which the whole building is shielded from the outside environment and information exchange inside the building is carried out by wireless communication. In order to effect this method, it has conventionally been attempted that metal plates or metal foils of iron, copper, aluminum or the like as electromagnetic wave shielding materials are laminated to building materials such as board materials or a wall material which shields electromagnetic wave is employed.

Further, at opening/closing portions such as doors and windows, a gasket for shielding electromagnetic wave is generally provided, so that the undesirable electromagnetic wave radiated from outside of the environment, as well as the electromagnetic wave which leaks from inside of the environment, can be shielded.

Examples of such a gasket include a gasket produced by the steps of: slicing an elastic foam block such as polyurethane sponge by a predetermined thickness by a slicer; cutting each slice to pieces having a predetermined width, thereby to obtain short, strap-like structures each having a rectangular section; optionally connecting one structure with another at the ends thereof, thereby to obtain a long, strap-like structure; and laminating a

conductive sheet around each strap-like structure by way of an adhesive agent layer, the conductive sheet being composed of an aluminum foil laminate film or a conductive woven cloth, and a gasket for shielding electromagnetic wave which is produced by providing a metal film on the strap-like structure itself, the gasket being positioned into gaps or opening/closing portions of electronic devices, or window portions of doors in intelligent buildings or FA factories.

As another example, there is a gasket manufactured by a continuous foaming method wherein a conductive woven fabric such as nylon woven fabric coated with silver is inserted into a mold to produce a cavity and a foamable material is introduced into the cavity and foaming the material simultaneously to produce the gasket continuously.

Also, there is known a gasket produced by slicing an elastic foam block such as polyurethane sponge, providing conductivity thereto by means of a plating and cutting each slice to pieces having a predetermined width, thereby to obtain strap-like structures each having a rectangular section.

[Objects of the Invention]

However, in the aforementioned methods in which the elastic foam strap-like structure (such as a sponge) is employed, there arises a problem that slicing is difficult to perform when extremely thin slices (e.g., no thicker

than 2 mm) are to be obtained, because slices are produced by slicing the sponge-like, elastic foam block by a predetermined thickness by a slicer, as described above. In order to overcome this problem, there has been made an attempt that the elastic foam block is sliced thicker than the predetermined thickness and the obtained slices are made to have a predetermined thickness by compressing the slices under an increased pressure and providing the slices with permanent strain or the elastic foam block is sliced thinner than the predetermined thickness and the obtained slices are laminated.

Although these thicker block may be sliced, the accuracy of dimension in the thickness direction is poor. Thus, the accuracy of dimension of the gaskets obtained by adhering a conductive sheet onto the elastic foam strap-like structure herically or by electroless-plating are insufficient. If these gaskets are used for the above electromagnetic wave shielding purpose, it is difficult to obtain a desired electromagnetic wave shielding property and also their production cost is expensive due to many production steps.

The above mentioned continuous method can produce gaskets with high productivity, but setting of the processing conditions (including selection of the raw material for effecting foaming, the charging and foaming method, the temperature condition) is difficult and thus high-standard control technique is required, resulting in a high facility cost. Further, in the gasket of such a type, the dimension

accuracy may be relatively poor because foaming tends to proceed to some extent even after the foamed product is pulled out of the mold. If these gaskets are used for the above electromagnetic wave shielding purpose, it is difficult to obtaine a desired electromagnetic wave shielding property.

In recent years, as the electric appliances are becoming thinner, a gasket material having thickness of 100-1000 μm or so is now increasingly in demand. This trend has made the aforementioned problem even more obvious.

The thickness of a conductive woven cloth produced by providing a woven cloth with conductivity is generally 60-200 μm or so, and the thickness of a conductive unwoven cloth produced by providing a unwoven cloth with conductivity is generally 60-500 μm or so. Such a conductive woven/unwoven cloth, which is made of only the conductive material, may be used as a thin gaslekt material. However, as the conductive woven/unwoven cloth made of only the conductive material exhibits poor cushioning property, the conductive woven/unwoven cloth of such a type is not suitable as a gasket material.

Further, the conductive material produced by forming a metal layer on the surface of a porous skeleton such as a strap-shaped, urethane sponge-like elastic foam structure (the polyurethane porous structure, in particular) has defects such as poor deterioration resistance property, although the conductive material of such a type shows

relatively excellent electromagnetic wave shielding property.

[Means for Attaining the Objects]

In order to attain the objects, the present invention firstly resides in an electromagnetic wave shielding material comprises a fibrous structure base material and a conductive metal layer, wherein the fibrous structure base material is a three dimensionally knitted base material.

It secondary resides in the electromagnetic wave shielding material of the above first characterized in that the electromagnetic wave shielding material comprises a fibrous structure base material and a conductive metal layer, wherein the fibrous structure base material is a three dimensionally knitted base material composed of an upper ground structure, a lower ground structure and connection thread..

It thirdly resides in the electromagnetic wave shielding material of the above second, characterized in that the three dimensionally knitted base material has a double raschel structure.

It fourthly resides in the electromagnetic wave shielding material of any one of the above first to third, characterized in that a heat-fusing thread is used at least a portion of the three dimensionally knitted base material.

It fifthly resides in the electromagnetic wave shielding material of any one of the above first to fourth,

characterized in that a conductive metal layer of the electromagnetic wave shielding material is coated with a synthetic resin.

In the present invention, the type of the base material is not particularly restricted as long as the base material can have a three dimensional structure. However, it is preferable to employ a three dimensionally (woven-)knitted base material, which includes, as main constituent members, an upper ground structure, a lower ground structure and a connection thread for connecting the upper ground structure and the lower ground structure and is produced by knitting by a double row needle bed type weaving-knitting machine. Among the three dimensionally knitted base material, that having the double raschel knitting structure is particularly preferable. The base material having such a structure exhibits excellent recovering property from compression, as well as excellent deterioration resistance property, and thus can be preferably used as an electromagnetic wave shielding material for a gasket or the like.

Examples of the connection thread used in the three dimensionally knitted base material of the present invention include: the connection thread having a normally intersecting connection thread which connects the upper ground structure with the lower ground structure in a manner that the connection thread (substantially) normally intersects the upper ground structure and the lower ground

structure; the connection thread having a diagonally intersecting connection thread which connects the upper ground structure with the lower ground structure in a manner that the connection thread diagonally intersects the upper ground structure and the lower ground structure; the connection thread having a truss structure which includes both the normally intersecting connection thread and the diagonally intersecting connection thread in a combined manner. In terms of effectively achieving the resilient elasticity of the base material and reducing the compressive residual strain, the connection thread having the diagonally intersecting connection thread is preferable.

Monofilament yarns are preferably used as the connection thread in order to reduce blocks at the time of cutting the gasket.

Also, it is preferable that the upper and lower ground structures are made by poor stretching structures.

Examples of the fiber material which constitutes the fibrous structure knitted base material include the conventionally known base materials such as synthetic fiber and natural fiber. Among these examples, polyester fiber which has excellent resilience recovering property and deterioration resistance property, is preferable.

Further, it is preferable that a polyester-based heat-fusing thread is used. The type of the heat-fusing thread to be used is not particularly restricted.

Especially, it is preferable to use a polyester-based heat-

fusing thread of the core-sheath composite type in which a high-melting point polyester is used for the core portion and a low-melting point polyester is used for the sheath portion.

The heat-fusing thread may be used at any of the upper ground structure, the lower ground structure and the connection thread of the three dimensionally knitted base material. Use of the heat-fusing thread at the portions which constitute the upper ground structure and the lower ground structure is particularly preferable.

The fibrous structure base material can be entirely composed of heat-fusing threads and also heat-fusing thread(s) and regular thread(s) can be mixed or they can be used partially.

By heat-setting the three-dimensionally knitted base material comprising the heat fusing threads, the connecting portions of the upper ground structure, the lower ground structure and the connection thread are bonded thereby reducing debris or blocks appeared at the cutting and lowering the compression residual strain significantly.

The metal layer formed on the base material may be provided by using the known methods such as spattering, vacuum deposition and plating. In order to evenly form the metal layer and achieve excellent conductivity and shielding property, it is preferable that the metal layer is formed by electroless plating. Electrolytic plating may optionally be carried out after carrying out the

electroless plating.

Examples of the metal to be used for forming the metal layer include known metals such as silver, copper, and nickel.

In order to reduce the amount of cutting debris generated at the time of cutting and suppress separation of the metal layer from the base material, it is preferable that the metalized base material is coated with a resin, after the metal layer is provided on the base material, but prior to cutting. The type of the resin to be coated is not particularly restricted, and may be a thermoplastic resin or the like. In terms of achieving excellent workability and flexibility, an acrylic resin is preferable.

By adding various types of flame retardant, the fire retardancy of the product can be improved. Examples of the flame retardant include: the halogen-based flame retardant represented by bromine-based and chlorine-based flame retardant; the antimony-based flame retardant such as antimony trioxide; and the phosphorus-based flame retardant. These examples of the flame retardant may be used solely or in a combined manner. The combination of the bromine-based flame retardant and the antimony-based flame retardant, in particular, exhibits an excellent effect in use. Examples of the method of providing the flame retardant include padding, knife coating, and gravure coating of the mixture of the flame retardant and a solvent-based or water-based synthetic resin. As the fire retardancy of the product is

improved as a result of adding the flame retardant, the product can be used in the fields where excellent fire retardancy is required, such as electric appliances for domestic use.

As described above, the electromagnetic wave shielding material of the present invention employs the three dimensionally knitted base material such as the double raschel knitting structure. Accordingly, by setting the types of the thread to be used, the denier of the thread, the number of filament count, the knitting structure and/or the knitting density in an appropriate manner, the properties of the electromagnetic wave shielding material such as flexibility and residual stain after load-release can be controlled.

Further, the electromagnetic wave shielding material of the present invention can be used, not only for a gasket, but also for a taping material (a grounding material).

[Embodiments of the Invention]

Hereinafter the embodiments of the present invention will be explained.

[Examples]

The present invention will be specifically demonstrated by the following examples. The method of measurement used in the examples are as follows.

1. Thickness

Measurement was made according to JIS L-1098

The measuring device: At-constant-pressure thickness measuring device TYPE PF-11 (manufactured by Rafurokku Co.)

2. Pressure observed when the sample was compressed by 50 %

A sample which had been cut into 10 mm × 10 mm size was placed on a pressure receiving plate and compressed at the compression rate of 0.5 mm/sec. The load was recorded when the thickness of the sample shrank to 50 % of the original thickness. The measured load was divided by the area of the sample, whereby the pressure at the time of 50 % compression was obtained.

3. Shielding property

The shielding property was measured according to the KEC method, by using a sample of 120 mm × 120 mm size. Specifically, the sample was placed between the antenna for transmission and the antenna for reception in a shielded box, and the strength of the received electromagnetic wave was measured. The damping rate (dB) was obtained from the ratio of the strength value of the received electromagnetic wave with respect to the strength value of the received electromagnetic wave when the sample was not present.

4. Compression residual strain

Measurement is made according to JIS K-6400.

A sample piece is compressed to 50% of the initial thickness by using two compression plates.

The compressed sample piece was treated at 70°C for 22

hours. The sample piece is removed from the compression plates and allows to stand for 30 minutes under standard conditions and the residual strain after recovery is measured.

5. Metal separation

A sample of 50 mm × 50 mm size was placed on a white cloth. A roller of 500 g weight was placed on the sample. The roller was reciprocally operated on the sample 250 times, and then the condition of metal layer separation (peeling off) was visually evaluated.

○: Separation of metal was hardly observed.

△: Separation of metal was slightly observed.

×: Significant sepration of metal was observed.

6. Cutting debris

The generation of cutting debris at the time of cutting the sample with a pair of scissors was visually observed.

◎: Cutting debris was hardly generated.

○: Cutting debris was slightly generated.

△: Cutting debris was moderately generated.

×: Cutting debris was significantly generated.

Example 1

A double raschel three dimensionally knitted structure was produced by using a double raschel knitting device. Polyester fiber of 33 dtex/12f was used as the ground structures 1 and 2. Monofilament made of polyester fiber of 22 dtex was used as the connection thread. A blank

product of 24 course/inch and 22 well/inch was obtained.

Ground structure: L1(L6):86/02, L2(L5):02/20

Connection structure: L3:02/24/42/20

Next, the obtained blank product was scoured and dried, whereby excess oil contents and impurities were removed. Thereafter, the blank product was immersed, for two minutes, in an aqueous solution at the temperature of 40° C which contained 0.3 g/L of palladium chloride, 30 g/L of tin (I) chloride, and 300 ml/L of 36 % hydrochloric acid. The blank product was then washed with water. Thereafter, the blank product was immersed, for five minutes, in borofluoric acid whose acid concentration was 0.1 N at the temperature of 30° C. The blank product was then washed with water. Next, the blank product was immersed, for five minutes, in an electroless copper plating solution at the temperature of 30° C which contained 7.5 g/L of copper sulfate, 30 ml/L of 37 % formalin, and 85 g/L of Rochelle salt. The blank product was then washed with water. Thereafter, the blank product was immersed, for ten minutes and at the electric current density of $5A/dm^2$, in an electrolytic nickel plating solution of pH 3.7 at the temperature of 35° C which contained 300 g/L of nickel sulfamate, 30 g/L of boric acid, 15 g/L of nickel chloride, whereby nickel was plated on the product. The blank product was then washed with water. The obtained metal-coated, three dimensionally knitted structure was immersed in the acrylic resin emulsion ("Primal TR-934",

manufactured by NIPPON ACRYL KAGAKUSHA) for 30 seconds, so that excess resin was removed. The product was then dried, whereby an electromagnetic wave shielding material whose conductive metal layer was coated with the acrylic resin was obtained. The obtained electromagnetic wave shielding material exhibited little variation in thickness thereof, compression residual strain and shielding property which were as excellent as those of the gasket employing the conventional foam, and significantly reduced level of metal separation and cutting debris generation. The observed performances are summarized in Table 1.

Example 2

A double raschel three dimensionally knitted structure was produced by using a double raschel knitting device. Polyester fiber of 33 dtex/12f was used at the ground structures 1 and 2. Polyester-based heat-fusing monofilament thread of 22 dtex was used as the connection thread. A blank product of 43 course/inch and 24 well/inch was thus obtained.

Ground structure: L1(L6):88/00, L2(L5):02/20

Connection structure: L3:02/24/42/20

Then, the blank product was treated in the same manner as in Example 1 to obtain an electromagnetic wave shielding material coated with copper and nickel. The obtained gasket exhibited little variation in thickness thereof, compression residual strain and shielding property which

were as excellent as those of the gasket employing the conventional foam, and significantly reduced level of metal separation and cutting debris generation. The observed performances are summarized in Table 1.

Example 3

A double raschel three dimensionally knitted structure was produced by using a double raschel knitting device. Polyester fiber of 33 dtex/12f was used at the ground structures 1 and 2. Polyester-based heat-fusing composite thread (the core thereof made of regular polyester and the sheath thereof made of low-melting point polyester was used. Monofilament made of regular polyester fiber of 22 dtex was used as the connection thread. A blank product of 43 course/inch and 24 well/inch was thus obtained.

Ground structure: L1(L6):86/02, L2(L5):02/20

Connection structure: L3:02/24/42/20

Next, the obtained blank product was scoured and dried, whereby excess oil contents and impurities were removed. Then, the ground structure and the connection yarn were bonded by drying (heat-set) at 160°C. Thereafter, the blank product was immersed, for two minutes, in an aqueous solution at the temperature of 40°C which contained 0.3 g/L of palladium chloride, 30 g/L of tin (I) chloride, and 300 ml/L of 36 % hydrochloric acid. The blank product was then washed with water. Thereafter, the blank product was immersed, for five minutes, in borofluoric acid whose acid

concentration was 0.1 N at the temperature of 30° C. The blank product was then washed with water. Next, the blank product was immersed, for five minutes, in an electroless copper plating solution at the temperature of 30° C which contained 7.5 g/L of copper sulfate, 30 ml/L of 37 % formalin, and 85 g/L of Rochelle salt. The blank product was then washed with water. Thereafter, the blank product was immersed, for ten minutes and at the electric current density of $5A/dm^2$, in an electrolytic nickel plating solution of pH 3.7 at the temperature of 35° C which contained 300 g/L of nickel sulfamate, 30 g/L of boric acid, 15 g/L of nickel chloride, whereby nickel was plated on the product. The blank product was then washed with water. On the surface of foam cells a nickel, copper and nickel layers were formed in this order uniformly. The product was cut in the direction of width to obtain strap-like structures each having a rectangular section. The observed performances are summarized in Table 1.

Comparative Example 1

A plain fabric was prepared at a warp density of 160/inch and a welf density of 95/inch by using polyester fiber 56T/36f.

Next, the obtained fabric was scoured and dried, whereby excess oil contents and impurities were removed. Thereafter, the fabric was treated in the same manner as in Example 1 to obtain a conductive fabric coated with copper

and nickel.

The observed performances are summarized in Table 1.

Comparative Example 2

An elastic foam block made of polyether-based polyurethane having cell density of being 45 cell/inch was sliced by 2 mm by a slicer. After scoring and washing, the product was immersed, for two minutes, in an aqueous solution at the temperature of 40° C which contained 0.3 g/L of palladium chloride, 30 g/L of tin (I) chloride, and 300 ml/L of 36 % hydrochloric acid. The blank product was then washed with water. Thereafter, the blank product was immersed, for five minutes, in borofluoric acid whose acid concentration was 0.1 N at the temperature of 30° C. The product was then washed with water. Next, the product was immersed, for five minutes, in an electroless nickel plating solution at the temperature of 35° C which contained 15 g/L of nickel sulfate, 10 ml/L of 37 % sodium hypophosphite, and the pH was adjusted to 8.1 with ammonia and sodium hydroxide. The product was then washed with water. Thereafter, the nickel-deposited product was immersed, for five minutes, in an electroless copper plating solution at the temperature of 30° C which contained 7.5 g/L of copper sulfate, 30 ml/L of 36 % formalin, and 85 g/L of Rochelle salt. The blank product was then washed with water. Thereafter, the product was immersed, for ten minutes and at the electric current density of $5A/dm^2$, in

an electrolytic nickel plating solution of pH 3.7 at the temperature of 35°C which contained 300 g/L of nickel sulfamate, 30 g/L of boric acid, 15 g/L of nickel chloride, whereby nickel was plated on the product. The product was then washed with water. On the surface of foam cells a nickel, copper and nickel layers were formed in this order uniformly. The product was cut in the direction of width to obtain strap-like structures each having a rectangular section. The observed performances are summarized in Table 1.

Table 1

	Thickness (mm)	Scatter in Thickness (mm)	Compression Residual Strain (%)	Shielding property (dB 100MHz)	Metal Separation	Cutting debris
Ex.1	2.0	±0.02	15	81.4	◎	◎
Ex. 2	2.0	±0.02	14	82.8	○	○
Ex. 3	2.0	±0.02	9	84.8	○	◎
Com. Ex. 1	0.1	±0.01	5	76.2	○	△
Com. Ex. 2	2.0	±0.50	13	88.4	○	×
Com. Ex. 3	2.0	+0.30	33	103.4	△	×

[Effects of the invention]

The present invention provides an electromagnetic wave shielding material, which has an excellent dimensional accuracy, constant thickness, compression residual strain and shieldability even in the case of a thin gasket as compared with conventional foam gaskets and also the cutting debris and the metal separation are little generated.

[Brief Description of the Drawing]

Fig. 1 is a schematic sectional view of one example of a three dimensionally knitted base material of the present invention.

[Explanation of Numerals]

1. Upper ground structure
2. Lower ground structure
3. Connection thread

[Document] ABSTRACT

[Object]

To provide a gasket for shielding electromagnetic wave which has an excellent dimensional accuracy and a less compression residual strain even if the thickness is relatively small.

[Construction]

Fiber structure obtained by forming a conductive metal layer on a three dimensionally knitted base material.

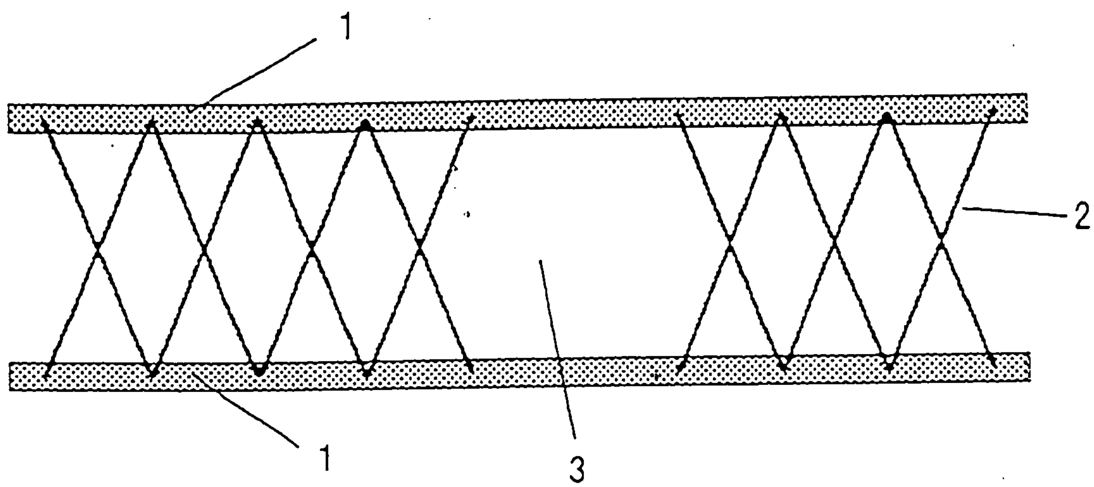

FIG. 1